

STUDY OF THE VIBROLITHIC METHOD OF FINISHING CONCRETE

A THESIS

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A FAIR ESTIMATE OF THE TOTAL PAVING WITHIN FULTON COUNTY AND ATLANTA, GEORGIA WOULD PLACE THE TOTAL AT CLOSE ON TO TWO THOUSAND MILES, INCLUDING ALL TYPES. OF THIS TOTAL, APPROXIMATELY 4,500,000 SQUARE YARDS HAVE BEEN LAID BY THE VIBROLITHIC METHOD. THIS IS EQUIVALENT TO ABOUT 425 MILES OF 18 FT PAVEMENT AND MIGHT ROUGHLY BE SAID TO BE 20% OF THE TOTAL OF ALL PAVING IN BOTH THE CITY OF ATLANTA AND FULTON COUNTY. WITH THIS IN MIND IT CAN READILY BE SEEN THAT FOR A CAREFUL STUDY OF THIS METHOD OF FINISHING CONCRETE, IT WOULD BE DIFFICULT TO FIND A LOCATION MORE SUITABLE THAN THIS SECTION MENTIONED.

VIBROLITHIC CONCRETE IS NOT A NEW TYPE OF PAVING MATERIAL IN THIS LOCALITY AS MAY BE JUDGED FROM THE AMOUNT OF IT THAT IS NOW UNDER TRAFFIC. THE FIRST PAVEMENT OF THIS TYPE LAID ON WHITEHALL STREET IN 1917 AND IS STILL GIVING EXCELLENT SERVICE AND IS IN GOOD CONDITION. DURING THE FIVE YEAR PERIOD FROM 1917 TO THE CLOSE OF 1921 A TOTAL OF 706,092 SQUARE YARDS OF VIBROLITHIC WAS LAID IN THE SOUTHEASTERN DIVISION. THE FIVE YEARS FOLLOWING THIS SAW A REMARKABLE INCREASE IN THE YARDAGE LAID AND REACHED THE TOTAL OF 2,743,862 SQUARE YARDS. SINCE THAT TIME THE USE OF THIS TYPE OF PAVEMENT HAS CONTINUED TO GROW UNTIL AT THE PRESENT TIME, THE PERCENTAGE OF THE TOTAL PAVING IN THE CITY AND COUNTY HAS REACHED THE FIGURE GIVEN ABOVE. ATTENTION IS CALLED THESE FIGURES SO THAT IT WILL BE UNDERSTOOD THAT THIS IS NOT A STUDY OF A TYPE OF PAVEMENT THAT HAS BEEN USED ONLY ON A SMALL SCALE BUT ONE THAT IS IN QUITE GENERAL USE.

IN ORDER THAT WE MAY MORE FULLY STUDY THE VIBROLITHIC METHOD OF FINISHING CONCRETE STREETS AND PAVEMENTS, IT WILL NOT BE AMISS AT THIS TIME TO OUTLINE BRIEFLY THE METHOD OF FINISHING AND LAYING PLAIN CONCRETE AND THUS BE ABLE TO UNDERSTAND THE DIFFERENCE BETWEEN THIS AND THE VIBROLITHIC CONCRETE. CONCRETE IS AN ARTIFICIAL STONE MADE BY CEMENTING TOGETHER A MINERAL AGGREGATE WITH PORTLAND CEMENT. THIS IS ACCOMPLISHED BY MIXING CAREFULLY IN SOME SUITABLE TYPE OF MIXER, THE COARSE AGGREGATE WHICH MAY CONSIST OF CRUSHED ROCK, SLAG OR GRAVEL, THE FINE AGGREGATE WHICH MAY CONSIST OF SAND OR SCREENINGS FROM A CRUSHER PLANT, AND PORTLAND CEMENT TOGETHER WITH A SUITABLE QUANTITY OF WATER TO PRODUCE A WORKABLE MIXTURE. IN THIS DISCUSSION THERE IS HARDLY TIME TO DO MORE THAN TO TOUCH ON THE PROPORTIONING OF THE MATERIALS TO PRODUCE GOOD CONCRETE AND IT WILL BE SUFFICIENT TO ONLY SAY THAT THE GENERAL SPECIFICATION FOR PLAIN CONCRETE IS EITHER 1:2:4 OR 1:1½:3 OR SOME SUCH SET PROPORTION. THE MAJORITY OF THE CONCRETE PLACED ON THE STREETS AND PAVEMENTS HERE IN THIS LOCALITY HAS BEEN ON THE 1:2:4 BASIS WHERE PLAIN CONCRETE HAS BEEN USED, WHILE THE PROPORTIONS FOR VIBROLITHIC CONCRETE LAID UNDER THE SAME CONDITIONS WILL BE 1:2:4½. THE MATERIALS AFTER BEING PROPORTIONED OUT PROPERLY ARE INTRODUCED INTO THE MIXER ALONG WITH THE CORRECT AMOUNT OF WATER TO PRODUCE THE PROPER WORKABILITY OR CONSISTENCY. MIXING SHOULD CONTINUE FOR NOT LESS THAN ONE MINUTE TO PRODUCE A GOOD QUALITY OF CONCRETE. THE CONCRETE AFTER BEING MIXED IS DISCHARGED INTO A BUCKET MOUNTED ON A SWINGING BOOM AND CAN THUS BE DISCHARGED OR DUMPED AT THE POINT DESIRED. IT IS THEN SPREAD TO THE PROPER THICKNESS BY RAKING IT OR OTHER

SUITABLE MEANS AND MAY NEXT BE STRUCK OFF WITH A TEMPLATE OR STRIKE BOARD WHICH IS CUT TO THE PROPER CONTOUR AND IS NOW READY TO BE COMPACTED OR FINISHED. ALL CONCRETE SHOULD BE COMPACTED IN ORDER TO PRODUCE THE BEST RESULTS AND THE QUALITY OF THE FINISHED PRODUCT IS LARGELY DEPENDENT ON THE PROPER COMPACTING OF THE CONCRETE IN THE ROADWAY. THIS COMPACTING MAY BE ACCOMPLISHED BY USING A METAL TAMPER OF SUITABLE SIZE AND WEIGHT OR BY SPADING OR PUDDLING OR BY ROLLING WITH A LIGHT SHEET STEEL ROLLER KNOWN AS THE MACON ROLLER. THE MACON ROLLER IS THE MOST COMMON TYPE OF WHAT MIGHT BE TERMED "HAND FINISHING" OF A CONCRETE PAVEMENT. THIS ROLLER IS FROM 8 TO 12 INCHES IN DIAMETER AND FROM 3 TO 5 FEET IN LENGTH AND WILL VARY IN WEIGHT FROM 10 TO 12 POUNDS PER FOOT. IT IS OPERATED BACK AND FORTH ACROSS THE PAVEMENT, WORKING FORWARD AT THE SAME TIME, AND FROM 2 TO 4 ROLLINGS MAY BE REQUIRED. FOLLOWING THE ROLLING, THE SURFACE MAY BE FLOATED UP WITH A LONG-HANDLED OR AN ORDINARY FLOAT AND THEN EITHER FINISHED BY BELTING WITH A CANVAS OR RUBBER COMPOSITION BELT OR BY DRAGGING A ONE INCH GARDEN HOSE OVER THE SURFACE. THE CONCRETE IS THEN READY TO BE CURED.

FROM THE POINT WHERE THE MACON ROLLER COMES INTO USE, THE CONCRETE MAY BE MACHINE FINISHED BY SOME TYPE OF SPECIAL MACHINE SUCH AS THE LAKEWOOD FINISHER, OR THE LEROI OR THE ORD, WHICH STRIKES THE CONCRETE TO THE PROPER CONTOUR, TAMP OR COMPRESSES IT INTO PLACE AND THEN SMOOTHES THE SURFACE BY A MECHANICALLY OPERATED TEMPLATE AND FOLLOWS THIS BY A BELT. NATURALLY ONE OF THESE MACHINES WILL GIVE A MUCH MORE UNIFORM FINISH TO THE CONCRETE AND THUS GIVE BETTER RESULTS. ANOTHER BIG ADVANTAGE OF THE

MACHINE FINISHING IS THAT IT PRODUCES A PAVEMENT WITH A SMOOTHER SURFACE THAT IS LESS APT TO BE WAVEY AS THE FINISHER RUNS ON A TRACK SET ALONG THE SIDE OF THE CONCRETE. THE CURING WOULD BE THE SAME IN EITHER CASE AND MIGHT BE ACCOMPLISHED BY ONE OF SEVERAL METHODS SUCH AS SPRINKLING WITH WATER AT REGULAR INTERVALS, OR BY COVERING WITH EARTH, STRAW OR BURLAP AND KEEPING THE COVERING WET, OR IT MIGHT BE CURED BY BUILDING LITTLE EARTH DAMS AND PONDING OR FLOODING THESE WITH WATER. THEN TOO THERE ARE A VARIETY OF CURING AGENTS ON THE MARKET SUCH AS CALCIUM CHLORIDE WHICH MAY BE SPRINKLED OVER THE SURFACE AND THUS COLLECTS MOISTURE OUT OF THE AIR AND KEEPS THE SURFACE MOIST. THIS PARTICULAR CURING AGENT HAS THE UNDESIRABLE PROPERTY OF DRAWING THE MOISTURE FROM THE CONCRETE RIGHT AT THE SURFACE OF THE PAVEMENT DURING LONG DRY SPELLS AND IN THIS WAY DOES MORE HARM THAN GOOD AND WILL VERY LIKELY RESULT IN THE CONCRETE SCALING UNDER THESE CONDITIONS. HOWEVER UNDER FAVORABLE CONDITIONS, THE USE OF CALCIUM CHLORIDE WILL GIVE GOOD RESULTS BUT SHOULD BE USED ONLY THE CONDITIONS ARE RIGHT AND THEN ACCORDING TO THE DIRECTIONS SET FORTH BY THE MANUFACTURER. LATER PRACTICE SEEMS TO FAVOR THIS MATERIAL AS AN ADMIXTURE AND NOT AS SURFACE TREATMENT ALTHOUGH IT IS STILL USED ON THE SURFACE IN SOME LOCALITIES.

THE FOREGOING DISCUSSION NOW BRINGS US TO THE VIBROLITHIC METHOD OF FINISHING CONCRETE. THIS METHOD TAKES UP THE WORK AT THE POINT WHERE THE FRESH AND SOFT CONCRETE IS RAKED OR SPREAD TO THE PROPER DEPTH AND CONTOUR AND CONSISTS OF COMPACTING THE CONCRETE BY VIBRATION RATHER THAN FINISHING BY ROLLING OR TAMPING. THE RESULTS OBTAINED BY THIS METHOD OF COMPACTING THE CONCRETE

ARE WORTHY OF CONSIDERABLE STUDY AND A MUCH LONGER DISCUSSION THAN CAN BE GIVEN IN THIS ARTICLE. AFTER THE CONCRETE HAS BEEN RAKED TO APPROXIMATELY THE PROPER GRADE AND STRUCK OFF WITH A STRIKE BOARD OR TEMPLATE, AN EXTREMELY HARD GRADE OR STONE SUCH AS A HIGH WEAR RESISTING GRANITE, OR A TRAP ROCK OR A HARD LIMESTONE STONE IS CAST OVER THE SURFACE OF THE FRESH CONCRETE IN SUCH QUANTITY THAT IT WILL "LOAD" THE UPPER INCH OR TWO OF THE CONCRETE. THIS QUANTITY OF STONE MAY RUN AS HIGH AS FIFTY OR SIXTY POUNDS PER SQUARE YARD OF PAVEMENT BUT IS NATURALLY DEPENDENT ON THE GRADING OF THE AGGREGATES IN THE CONCRETE AND THE AMOUNT OF MORTAR THAT CAN BE VIBRATED UP TO THE SURFACE TO TAKE UP THIS SURFACE ROCK. NARROW FLEXIBLE PLATFORMS ARE PLACED UPON THIS STONE AND A VIBRATOR IS ROLLED BACK AND FORTH OVER THE PLATFORMS UNTIL THE BOTTOM EDGES ARE BROUGHT TO A TRUE GRADE AND THE SURFACING STONE IS PERFECTLY IMBEDDED IN THE SLAB. THE VIBRATOR PERFORMS THE DOUBLE FUNCTION OF IMBEDDING THE STONE WHILE DENSIFYING THE MASS. THIS MAY BE EXPLAINED IN THE FOLLOWING MANNER. VIBRATIONS ARE THE MOST EFFECTIVE AGENTS IN COMPACTING MASSES MADE UP OF ANGULAR PARTICLES. FOR EXAMPLE, A BARREL OF TACKS CANNOT BE READILY COMPRESSED INTO A SMALLER BODY BUT A GREAT REDUCTION CAN BE BROUGHT ABOUT BY SHAKING OR VIBRATING THE BARREL. THIS SAME ACTION WILL TAKE PLACE IF THE BARREL CONTAINS ANGULAR PARTICLES SUCH AS BROKEN STONE OR SLAG SUCH AS USED IN CONCRETE. THUS THE VIBRATION THAT IS APPLIED TO THE CONCRETE THROUGH THE PLATFORMS CAUSES THE AGGREGATE TO WORK CLOSER TOGETHER AND FORM A DENSER MASS. THIS NECESSITATES THE WORKING UP TO THE SURFACE OF THE MORTAR THAT WAS BETWEEN THESE PARTICLES, OR RATHER A PORTION OF IT, SO THAT

THE COARSE AGGREGATE NOW LIES CLOSER TOGETHER AND THE MORTAR FILLED SPACES BETWEEN THESE PARTICLES HAS BEEN MATERIALLY DECREASED.

THIS ENABLES US TO UNTILIZE THIS MORTAR WHICH NOW MIGHT BE CONSIDERED

AS EXCESS, TO TAKE UP THE SURFACING ROCK WHICH WAS ADDED BEFORE THE VIBRATOR PLATFORMS WERE PLACED OVER THE SURFACE. IN THIS WAY THE CONCRETE NOW CARRIES AN EXTRA QUANTITY OF STONE WHICH IN ITSELF TENDS TO GIVE IT GREATER STRENGTH UNDER COMPRESSIVE FORCES. IN ADDITION TO THIS HOWEVER, WE ARE ABLE TO ADD AN UNUSUALLY GOOD WEAR RESISTING ROCK RIGHT IN THE SURFACE WHERE IT WILL BE ABLE TO WITHSTAND THE ABRASIVE FORCES OF TRAFFIC AND GIVE THE PAVEMENT LONGER LIFE. THE VIBRATION HAS STILL ANOTHER PROPERTY AND THAT IS A MORE UNIFORM DISTRIBUTION OF THE MORTAR THROUGHOUT THE ENTIRE THICKNESS OF THE CONCRETE SO THAT THERE IS NOT THE TENDENCY TOWARD HONEY-COMBING THAT MIGHT BE FOUND IN CONCRETE THAT WAS HAND FINISHED. THIS DISTRIBUTION OF THE MORTAR WILL GIVE MORE UNIFORM STRENGTH AND AT THE SAME TIME WILL INSURE DENSITY OF THE CONCRETE. DENSITY IS A MOST IMPORTANT REQUIREMENT OF GOOD CONCRETE; FIRST, BECAUSE THE BEAM STRENGTH AND SUPPORTING CAPACITY ARE LARGELY DEPENDENT UPON IT; SECOND, BECAUSE DENSITY WILL DECREASE THE MOISTURE ABSORPTION; THIRD, BECAUSE DENSITY OR CLOSE RELATION BETWEEN THE PARTICLES INCREASES THE BINDING PROPERTIES OF THE CEMENT. IT IS ALSO POSSIBLE TO USE A MUCH DRIER MIX WHEN VIBRATING AND THIS FEATURE WILL GIVE MUCH STRONGER CONCRETE IN ACCORDANCE WITH THE WATER-CEMENT RATIO THEORY. THIS THEORY MIGHT BRIEFLY BE STATED AS FOLLOWS: PROVIDED THAT THE MATERIALS ARE SOUND AND DURABLE AND THE MIXTURE IS WORKABLE AND PLASTIC, THE STRENGTH OF THE CONCRETE VARIES INVERSELY WITH THE RATIO OF WATER TO THAT OF THE CEMENT. THIS IS A VOLUMETRIC RATIO OF WATER TO CEMENT.

IN ORDER THAT THE VIBROLITHIC PROCESS MAY BE BETTER UNDERSTOOD, A RATHER COMPLETE SET OF PICTURES HAVE BEEN SECURED AND AN EFFORT HAS BEEN MADE TO PICTURE CLEARLY EACH AND EVERY STEP IN ITS PROPER ORDER. UNDER EACH PICTURE IS TO BE FOUND A CLEAR DESCRIPTION OF JUST WHAT IS SHOWN SO THAT THERE IS NO NEED FOR A LENGTHY DISCUSSION AT THIS POINT.

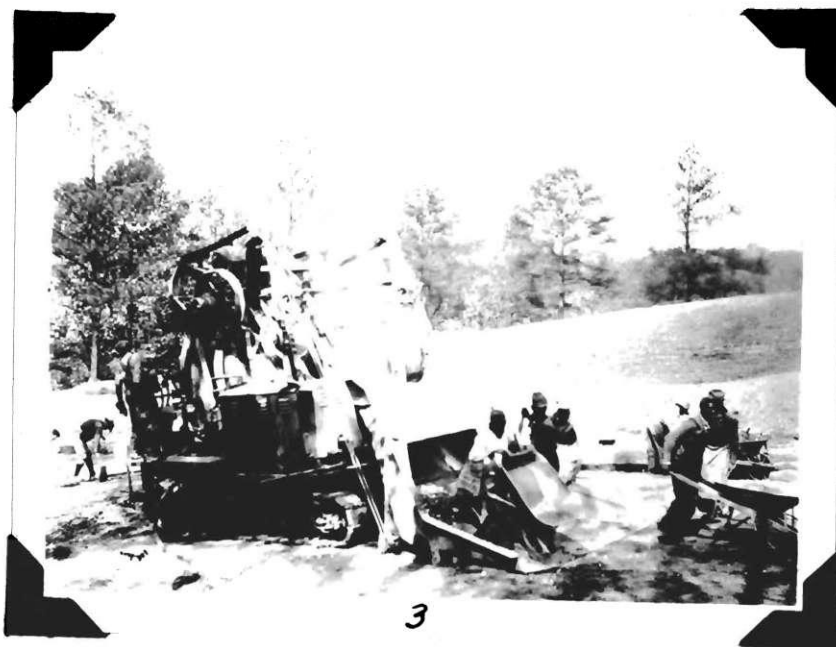


PICTURE NO.1. SHOWING A TYPICAL LAYOUT OF MATERIALS PILED ON THE SUBGRADE AHEAD OF THE MIXER. THIS IS A CASE WHERE THE MATERIALS ARE PROPORTIONED RIGHT ON THE JOB AND ARE HANDLED BY MEANS OF WHEELBARROWS. THE SAND IS PILED IN THE IMMEDIATE FOREGROUND AND THE COARSE AGGREGATE, IN THIS CASE CRUSHED GRANITE, IS SHOWN ON THE RIGHT HAND SIDE OF THE ROAD. THE CEMENT, IN SACKS, IS SHOWN IN A PILE DOWN CLOSER TO THE MIXER WHERE IT CAN BE HANDLED BY HAND.



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PICTURE NO.2. DUMPING THE MATERIALS INTO THE MIXER SKIP. THE SAND AND COARSE AGGREGATE ARE HANDLED IN WHEELBARROWS AND THE CEMENT IS HANDLED ONE BAG AT THE TIME BY HAND, THE PROPER NUMBER OF SACKS BEING ADDED FOR EACH BATCH.



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PICTURE NO.3. A MORE GENERAL VIEW OF THE MIXER SKIP BEING CHARGED. THIS PICTURE ALSO SHOWS THE GENERAL DETAILS OF THE MIXER SUCH AS THE GASOLINE MOTOR WHICH DRIVES THE MIXER, THE MIXER DRUM, THE TANK FOR WATER, CATTERPILLAR TREAD, ETC.



PICTURE NO.4. SHOWING THE MIXER SKIP BEING RAISED TO DUMP THE MATERIALS INTO THE MIXER DRUM.

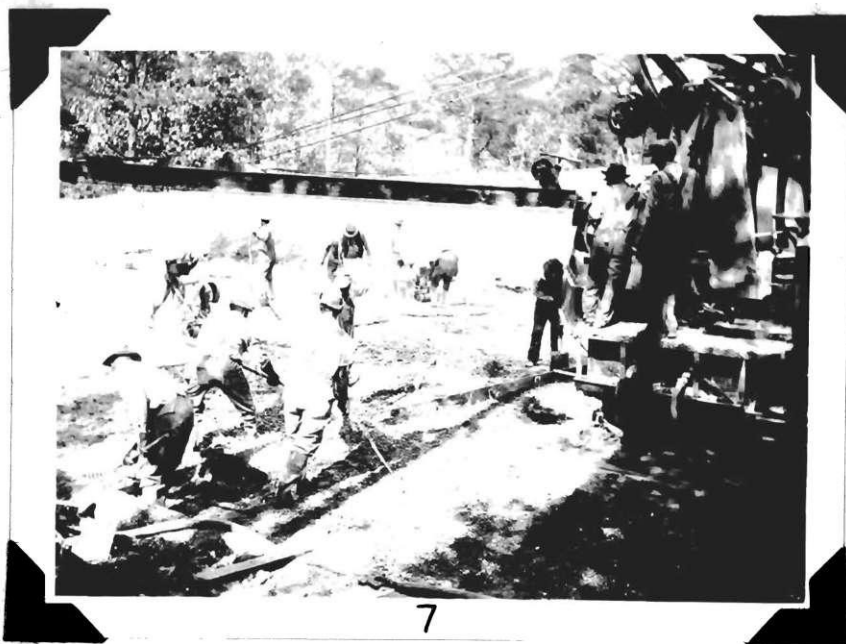


PICTURE NO.5. THE FRESH MIXED CONCRETE IS BEING DUMPED FROM THE BOTTOM DUMP BUCKET WHICH CAN BE RUN OUT TO THE DESIRED POINT ON THE BOOM WHICH IN TURN CAN BE SWUNG TO EITHER SIDE AS DESIRED.



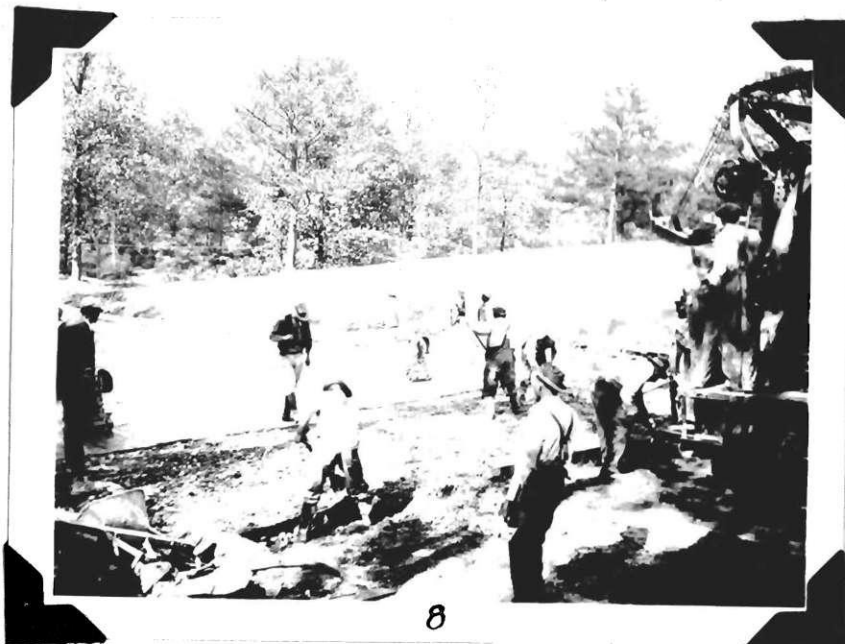
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PICTURE NO.6. THE FRESH MIXED CONCRETE IS NOW RAKED TO APPROXIMATE-
LY THE PROPER GRADE.



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PICTURE NO.7. CONCRETE BEING PLACED AT AN EXPANSION JOINT. THIS
JOINT CONSISTS OF A ONE INCH PINE BOARD THE FULL DEPTH OF THE
PAVEMENT AND TREATED WITH CREOSOTE.



PICTURE NO.8. ANOTHER VIEW OF THE CONCRETE BEING PLACED ALONG AN EXPANSION JOINT.



PICTURE NO.9. THE CASTING ROCK BEING SCATTERED OVER THE SURFACE OF THE UNCOMPACTED CONCRETE. THIS STONE IS DISTRIBUTED BY MEANS OF A HAND SHOVEL AS SHOWN IN THE RIGHT FORE-GROUND.



PICTURE NO.10. THE VIBRA-
TOR PLATFORMS BEING MOVED FO
FORWARD READY TO COMPACT
THE FRESH CONCRETE. THESE
PLATFORMS ARE MADE OF NAR-
ROW STRIPS OF WOOD FASTEN-
ED TOGETHER BY CLEATS
ON THE UPPER SIDE AT BOTH
ENDS AND THE MIDDLE. THE
CRACKS ALLOW THE EXCESS
WATER TO WORK UP THROUGH
THE PLATFORM AND THUS REMOVE
MOVES IT FROM THE CONCRETE.



PICTURE NO.10. A GENERAL VIEW SHOWING THE PLATFORMS BEING MOVED
UP INTO PLACE AND AT THE LEFT A VIBRATOR READY TO COMMENCE COM-
PACTING THE CONCRETE.



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PICTURE NO.12. IN THE CENTER OF THE PICTURE TWO VIBRATORS MAY BE SEEN IN OPERATION. THE VIBRATOR CONSISTS OF A ONE CYLINDER GASOLINE ENGINE WITH THE FLYWHEEL UNBALANCED SO AS TO IMPART THE NECESSARY VIBRATION TO PROPERLY COMPACT THE CONCRETE. THE ENGINE IS MOUNTED ON CAST IRON WHEELS WHICH ALLOW IT TO BE ROLLED BACK AND FORTH. THE GAS TANK IS ON THE FRAME WHICH SERVES AS A HANDLE.



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PICTURE NO.13. SHOWING THREE VIBRATORS AT WORK. THE EXCESS WATER WORKS UP THROUGH THE CRACKS BETWEEN THE SLATS AND WHERE THE CONCRETE IS EXCESSIVELY WET, IT SPOUTS UP IN SMALL INTERMITTENT STREAMS AN INCH OR TWO HIGH.



PICTURE NO.14. WHEN THE PLATFORMS ARE MOVED FORWARD, THE FRESHLY COMPACTED CONCRETE SHOWS THE "BOARD MARKS" AS SEEN IN THE PICTURE. THESE ARE SUPERFICIAL AND ARE REMOVED BY FLOATING UP THE SURFACE WITH A LONG HANDLED FLOAT.



PICTURE NO.15. GENERAL VIEW SHOWING THE PLATFORMS BEING MOVED UP, THE VIBRATORS AT WORK AND THE BOARD MARKS BEING FLOATED OUT WITH LONG HANDLED FLOAT.



PICTURE NO.16. FINISHING THE SURFACE BY DRAGGING A ONE INCH HOSE OVER THE SURFACE. ANY SMALL PLACES THAT NEED FURTHER FINISHING ARE FINISHED BY USING A HAND FLOAT.



PICTURE NO.17. THIS PICTURE SHOWS MR.F.H.FRASUER OF THE SOUTHEASTERN VIBROLITHIC CORP., ATLANTA, GA., STANDING ON THE FRESHLY COMPACTED CONCRETE NOT MORE THAN TEN MINUTES AFTER IT WAS DEPOSITED ON THE SUBGRADE BY THE MIXER. NOTE THAT HIS WEIGHT IS CARRIED ON THE CONCRETE AND NOT SINKING INTO THE SURFACE. FOOTPRINTS ARE HARDLY VISIBLE AFTER PUTTING FULL WEIGHT ON THE SURFACE.

THE VIBROLITHIC METHOD HAS BEEN APPLIED TO THE FINISHING OF CONCRETE LAID BETWEEN THE CAR TRACKS AND SEVERAL RATHER UNIQUE FEATURES ARE SHOWN IN THE FOLLOWING PICTURES TAKEN ON PEACHTREE ROAD JUST BEYOND BROOKWOOD STATION. ON THIS PARTICULAR JOB, A SPECIAL TYPE OF FILLER JOINT WAS LAID BOTH ON THE INSIDE AND OUTSIDE OF THE RAIL MADE FROM A PREMOLDED MIXTURE OF ASPHALT, FELT AND ASBESTOS. THIS PREVENTS THE RAIL FROM COMING IN DIRECT CONTACT WITH THE CONCRETE AND THUS MAKING THE PAVEMENT MUCH QUIETER AS WELL AS MAKING A WATERTIGHT JOINT BETWEEN THE CONCRETE AND THE RAIL. ANOTHER UNUSUAL FEATURE ON THE JOB WAS THE USE OF A WOODEN "TEMPLATE ROLLER" WEIGHING ABOUT 250 POUNDS AND EQUIPPED WITH A STEEL FLANGE WHICH ROLLS ON THE RAILS AND GIVES THE PROPER CONTOUR TO THE COMPACTED CONCRETE BETWEEN THE RAILS. IN OTHER RESPECTS THIS JOB IS HANDLED THE SAME AS A CONCRETE PAVEMENT, WITH THE EXCEPTION THAT THE CONCRETE WAS MIXED AT A CENTRAL MIXING PLANT AND HAULED TO THE JOB IN TRUCKS. THE TIME ELAPSED BETWEEN THE MIXING OF THE CONCRETE AND DISCHARGING OF THE TRUCKS ON THE JOB WAS ABOUT ONE HALF HOUR.



PICTURE NO. 18. FILLER IS SHOWN IN PLACE AND READY FOR THE CONCRETE TO BE PLACED AND VIBRATED.



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PICTURE NO.19. THE CONCRETE ON THIS PARTICULAR JOB WAS MIXED AT THE CENTRAL MIXING PLANT OF THE CITY AND HAWLED TO THE JOB IN TRUCKS. SOME IDEA OF THE CONDITION OF THE MATERIAL ON ITS ARRIVAL AT THE JOB CAN BE HAD FROM A STUDY OF THIS PICTURE, SHOWING THE TRUCK BODY ELEVATED AND DIGGING IT OUT WITH PICKS AND SHOVELS. THE GREATER PART SLIDES OUT VERY NICELY WHEN IT ONCE STARTS.



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PICTURE NO.20. GENERAL VIEW SHOWING THE ROLLER FOR FORMING THE CROWN IN THE FOREGROUND AND THE VIBRATOR AND VIBRATOR PLATFORMS JUST BEYOND THE ROLLER.



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PICTURE No.20. FINISHING THE SURFACE WITH A LONG HANDLED FLOAT AFTER IT HAS BEEN ROLLED TO THE PROPER CONTOUR FOLLOWING THE VIBRATOR.



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PICTURE No.22. THE FINAL FINISH IS MADE BY DRAGGING WITH A ONE INCH RUBBER GARDEN HOSE AND THEN PLACES THAT NEED TOUCHING UP A BIT ARE ATTENDED TO WITH A HAND FLOAT AS SHOWN.



PICTURE NO.23. THIS PICTURE SHOWS A GENERAL VIEW OF THE VOBROLITHIC CONCRETE BEING LAID BETWEEN THE CAR TRACKS ON PEACHTREE ROAD. AT THE LEFT THE GANG CAN BE SEEN JUST AFTER RAKING THE FRESH CONCRETE TO APPROXIMATELY THE CORRECT GRADE, THEN COMES THE PLATFORMS AND THE VIBRATOR, THE ROLLER TEMPLATE AND THE FINISHING HOSE.

HAVING FOLLOWED THE PROCESS STEP BY STEP THAT IS REQUIRED IN THE PLACING AND FINISHING OF VOBROLITHIC CONCRETE, IT MIGHT BE WELL AT THIS POINT TO STUDY THE EFFECT OF THE METHOD OF FINISHING THE CONCRETE BY COMPACTING. IN ORDER THAT A BETTER IDEA OF THIS COMPACTING MAY BE HAD IT IS WELL TO CONSIDER THE RESULTS OBTAINED ON A SERIES OF TESTS, RUN TO DETERMINE JUST HOW MUCH EFFECT THIS METHOD DID HAVE OVER THE ORDINARY METHOD. THESE TESTS INCLUDED A SERIES OF STANDARD SIZE COMPRESSION CYLINDERS, 6" DIAM BY 12" LENGTH; A SET OF THREE TEST SLABS 25" BY 25" AREA AND NORMALLY OF 5½" BERTH. BELOW IS GIVEN THE DATA ON THE SAMPLES AND THE RESULTS OBTAINED ON TESTING THEM.

6 BY 12 INCH CYLINDERS BROKEN AT 28 DAYS BY COMPRESSION. RESULTS ARE GIVEN IN POUNDS PER SQUARE INCH.

NO.1- PLAIN CONCRETE (STONE) FROM SLAB NO.1----- 2845#
 NO.2- VIBRATED CONCRETE (GRAVEL) FROM SLAB NO.3---- 3740#
 NO.3- VIBRATED CONCRETE (STONE) FROM SLAB NO.3----- 2670#
 NO.4- PLAIN CONCRETE (GRAVEL) FROM SLAB NO.3----- 2670#
 NO.5- PLAIN CONCRETE (STONE) FROM SLAB NO.2----- 2580#

CONSIDERABLE DIFFICULTY WAS HAD IN PROPERLY COMPACTING THESE SAMPLES BY VIBRATION DUE TO THE SMALLNESS OF THE SURFACE ON WHICH THE VIBRATOR HAD TO BE BALANCED AND THE DEPTH OF THE CONCRETE. IN THE PLAIN CONCRETE SAMPLES, THE FRESH CONCRETE WAS PLACED IN LAYERS OF APPROXIMATELY FOUR INCHES AND EACH LAYER RODDED THIRTY TIMES WITH A $5/8$ INCH ROD 21 INCHES LONG AND THE LOWER END SHAPED TO A BLUNT BULLET POINT. IN THE VIBRATED SAMPLES, THE VIBRATOR WAS PLACED ON A SMALL WOODEN DISK WHICH FITTED JUST INSIDE THE MOLD AND HAD SMALL HOLES DRILLED THROUGH IT TO ALLOW THE WATER TO ESCAPE. HOWEVER THE RESULTS OBTAINED ON THESE SAMPLES WOULD LEAD ONE TO BELIEVE THAT THE EFFECT OF VIBRATION IS NOT FELT TO ANY VERY APPRECIABLE EXTENT AT A DEPTH OF MORE THAN 8 OR 10 INCHES, PARTICULARLY WHERE THE MATERIAL IS CONFINED IN SUCH A CLOSE MOLD WHERE THE DIAMETER IS ONLY HALF THAT OF THE DEPTH BEING VIBRATED. FIGURES WHICH TEND TO BEAR OUT THIS FACT ARE SHOWN ON THE TESTS MADE ON CORES WHICH WERE DRILLED FROM THE SLABS AND THEN TESTED IN COMPRESSION.

SLABS. 25" x 25" x $5\frac{1}{2}$ ".

NO.1- VIBRATED CONCRETE (STONE) 1-2-4 MIX IN WHICH $5\frac{1}{2}$ INCHES OF PLAIN CONCRETE IS COMPACTED TO $4\frac{7}{8}$ INCHES. THE TOTAL VOLUME OF THE SAMPLE BEFORE VIBRATION WAS 2 CUBIC FEET AND ONLY ABOUT 15 POUNDS OF MORTAR WORKED UP THROUGH THE PLATFORM AND WAS

LOST. WHEN THE FACT THAT THE TOTAL WEIGHT OF THE SAMPLE WAS WITHIN A COUPLE OF POUNDS OF BEING 300, THIS SMALL AMOUNT IS PRACTICALLY NEGLIGIBLE. THIS COMPACTION OBTAINED BY VIBRATION WAS 0.60" OR 0.05' OVER THE SURFACE AREA OF 4.34 SQ. FT OR A TOTAL OF 0.217 CU. FT. THIS IS EQUAL TO 10.8% OF THE ORIGINAL VOLUME OF 2 CU FT.

SLAB. NO. 2. THE SAME MIX AND AMOUNT OF CONCRETE AS NO. 1 BUT FINISHED PLAIN.

SLAB NO. 3. ONE HALF OF THE SLAB OR ONE CUBIC FOOT MADE FROM A 1-2-4 MIX USING GRAVEL AND THE OTHER HALF MADE FROM A 1-2-4 MIX USING STONE. THE TOTAL QUANTITY OF MIXED MATERIALS BEING 2 CUBIC FEET, 3/10 CUBIC FOOT OF LIMESTONE IS ADDED TO THE SURFACE OF THE SLAB AND THEN VIBRATED, LEAVING THE FINAL DEPTH 5½ INCHES AS IN THE CASE OF THE PLAIN SAMPLE. THIS 3/10 OF A CU FT OF LIMESTONE HAD 35% VOIDS WHICH LEFT A TOTAL OF 0.195 CU FT OF SOLID MATERIAL THAT WAS ADDED WHEN THE SAMPLE WAS VIBRATED WITHOUT INCREASING THE DEPTH OF THE FINISHED SAMPLE. THIS AMOUNT CHECKS QUITE CLOSELY WITH THE 0.217 CU FT COMPACTION THAT WAS OBTAINED ON SLAB NO. 1.

THESE SLABS WERE BROKEN BY MEANS OF KNIFE EDGE SUPPORTS, BEING SUPPORTED ON TWO KNIFE EDGES AND LOADED AT THE CENTER. THE AGE OF THE SAMPLES AT THE TIME OF THIS TEST WAS 28 DAYS.

SLAB #1- FULL SLAB- TENSION IN BOTTOM, 25" WIDE x 4 ⁷ / ₈ "	:	11500#
#1- HALF SLAB- TENSION IN TOP, 12½" WIDE x "	:	3230#
#1- HALF SLAB- TENSION IN BOTTOM 12½" WIDE x "	:	5600#
SLAB #2- FULL SLAB- TENSION IN BOTTOM, 25" WIDE x 5½"	:	11300#
#2- HALF SLAB- TENSION IN TOP, 12½" WIDE x 5½"	:	5200#
#2- HALF SLAB- TENSION IN BOTTOM, 12½" WIDE x 5½"	:	4300#
SLAB #3- FULL SLAB- TENSION IN BOTTOM, 25" WIDE x 5½"	:	12100#
#3- HALF SLAB- TENSION IN TOP (STONE) 13" x 5½"	:	6700#
#3- HALF SLAB- TENSION IN TOP (GRAVEL) 10" x 5½"	:	4200#

A STUDY OF THESE RESULTS WILL SHOW THAT A MORE NEARLY UNIFORM STRENGTH IS DEVELOPED IN BOTH THE TOP AND BOTTOM OF THE VIBROLITHIC SAMPLE, THIS BEING No.3. ON BREAKING THE FULL SLAB, THE FAILURE OCCURRED THROUGH THE SIDE WITH THE GRAVEL AS THE LOAD WAS APPLIED ALONG THE LINE SEPARATING THE STONE AND GRAVEL SECTIONS. THIS WAS DUE TO THE MORTAR NOT HAVING DEVELOPED ITS FULL STRENGTH AND THEREFORE PULLING AWAY FROM THE GRAVEL RATHER THAN BREAKING THROUGH THE PEBBLES THEMSELVES. THIS FACT AND ALSO THE GRAVEL SECTION BEING ONLY 10 INCHES WIDE WHEN BROKEN WITH TENSION IN THE TOP WILL ACCOUNT FOR THE GRAVEL HALF RUNNING SO MUCH LOWER THAN THE STONE.

FROM THESE SECTIONS OF THE SLABS, CORES WERE DRILLED AND AFTER THE ENDS HAD BEEN BUILT UP LEVEL, THEY WERE BROKEN BY COMPRESSION. THE AGE OF THESE CORES AT THE TIME OF TEST WAS 42 DAYS WHICH IS EQUIVALENT TO APPROXIMATELY 114% OF THE 28 DAY STRENGTH.

CORES

#1- TOTAL LOAD 40,000 LBS, 3" DIAM X $4\frac{7}{8}$ " OR 5710 LBS/SQ. IN.

#2- TOTAL LOAD 37,500 LBS, 3" DIAM X $5\frac{1}{2}$ " OR 5210 LBS/SQ IN.

#3- SAMPLE FROM SIDE MADE WITH STONE.

TOTAL LOAD 45,000 LBS, 3" DIAM X $5\frac{1}{2}$ " OR 6430 LBS/SQ IN.

#3- SAMPLE FROM SIDE MADE WITH GRAVEL.

TOTAL LOAD 35,000 LBS, 3" DIAM X $5\frac{1}{2}$ " OR 5000 LBS/SQ IN.

NOW IF THESE RESULTS ARE FIGURED BACK TO EQUIVALENT STRENGTHS FOR 6 X 12 INCH CYLINDERS AT 28 DAYS IN WHICH IT IS NECESSARY TO NOT ONLY CORRECT FOR THE AGE OF THE CORES BUT ALSO TO TAKE INTO CONSIDERATION THE FACT THAT THE SAMPLES ARE NOT OF SUCH SIZE THAT THE HEIGHT IS TWICE THE DIAMETER, THE RESULTS ARE FOUND TO BE:

No.1--- 5010 LBS/SQ IN

No.3, ROCK---5640 LBS/SQ IN

No.2--- 4910 LBS/SQ IN

No.3, GRAVEL-4400 LBS/SQ IN

AGAIN IT IS FOUND THAT THE GRAVEL SAMPLE DOES NOT REACH THE SAME STRENGTH THAT IS FOUND IN THE SAMPLE MADE WITH BROKEN STONE BUT THERE IS A REASON FOR THE APPARENT WEAKNESS. IN DRILLING THE CONES, WHICH WAS ACCOMPLISHED BY THE USE OF A LARGE SIZE SHOT DRILL USING CHILLED STEEL SHOT AS A CUTTING AGENT, THE GRAVEL WAS SO CUT THAT PIECES WERE WEDGED OUT DUE TO THEIR ROUNDED SURFACES, RATHER THAN BEING DISPLACED DUE TO CRACKING. THIS WAS NOT TRUE WHERE THE GRAVEL WAS WELL SURROUNDED BY MORTAR BUT THE LOSS OF THE PIECES LESS FIRMLY BEDDED, NATURALLY WEAKEN THE SAMPLE MATERIALLY. WHERE NO CUTTING IS NECESSARY TO SECURE A SAMPLE, IT WILL BE FOUND THAT GRAVEL WILL GIVE STRENGTHS THAT ARE FAVORABLE TO THOSE SECURED BY THE OF CRUSHED STONE.

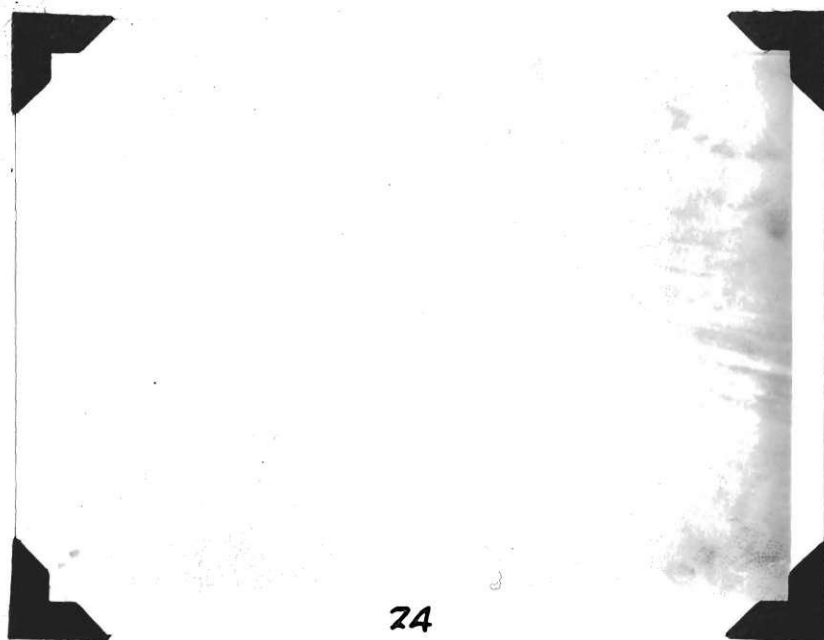
THESE TESTS SHOW QUITE CONCLUSIVELY THAT CONCRETE CAN BE COMPACTED SUCCESSFULLY BY MEANS OF VIBRATION SUCH AS IS APPLIED IN THE VIBROLITHIC PROCESS AND ALSO THERE IS A MORE UNIFORM DISTRIBUTION OF THE MORTAR THROUGHOUT THE ENTIRE DEPTH OF THE SAMPLE. THIS UNIFORM DISTRIBUTION OF THE MORTAR ALSO GIVES TO THE PAVEMENT A MORE UNIFORM STRENGTH TO WITHSTAND THE STRESSES THAT COME UPON IT.

SO FAR THE DISCUSSION HAS BEEN ON THE METHOD OF PLACING THIS TYPE OF PAVEMENT AND THE RESULTS OBTAINED ON TEST SAMPLES. IT IS THEREFORE IN ORDER THAT AN EXAMINATION BE MADE OF SEVERAL PAVEMENTS THAT HAVE BEEN UNDER TRAFFIC FOR VARYING LENGTHS OF TIME. THE APPEARANCE OF THE SURFACE WHEN THE PAVEMENT IS FIRST FINISHED IS VERY MUCH LIKE THAT OF ANY OTHER CONCRETE SURFACE AS THE MORTAR SURFACE HAS BEEN FINISHED BY DRAGGING A ONE INCH HOSE OVER IT OR BY BELTING WITH A FLAT CANVAS OR RUBBER AND FABRIC BELT. THIS MORTAR COVERING IS QUITE THIN ON THE VIBROLITHIC CONCRETE DUE TO THE SURFACING STONE WHICH WAS VIBRATED INTO THE SURFACE AND WAS FORCED INTO THE

CONCRETE BY THE PRESSURE OF THE PLATFORMS. NATURALLY THEY ARE THEN CLOSE TO THE SURFACE IN THE FINISHED PAVEMENT AND HERE ANOTHER FEATURE THAT IS TO THE ADVANTAGE OF THE WEARING QUALITIES OF VIBROLITHIC IS FOUND. THE TENDENCY OF THESE STONES UNDER THE ACTION OF THE VIBRATOR IS TO TURN SO AS TO EXPOSE THE FLATTER SIDE OR A GREATER AREA TO THE WEAR OF TRAFFIC RATHER THAN TO WORK DOWN IN THE SURFACE IN THE LONG DIRECTION. THIS ACTION CAN READILY BE UNDERSTOOD IF A NUMBER OF PIECES OF LOOSE STONE ARE PLACED IN A VESSEL AND SHAKEN OR AGITATED. THESE PIECES WILL LIE FLAT RATHER THAN REMAIN ON END. THE SAME ACTION CAN BE SHOWN IF THEY ARE PLACED ON THE SURFACE OF A BOX OF SAND AND WORKED DOWN INTO THE SAND BY HAMMERING OR POUNDING ON THE BOARD PLACED OVER THEM. NOW KEEPING IN MIND THE FACT THAT THE MORTAR IS NOT ABLE TO WITHSTAND THE SAME AMOUNT OF WEAR AS THE STONE ITSELF, IT IS EASY TO SEE THAT THE LOADING OF THE UPPER SURFACE WITH AN EXTRA QUANTITY OF HIGH WEAR RESISTING STONE WILL GIVE THE PAVEMENT MUCH GREATER RESISTANCE TO THE ABRASIVE ACTION OF TRAFFIC.

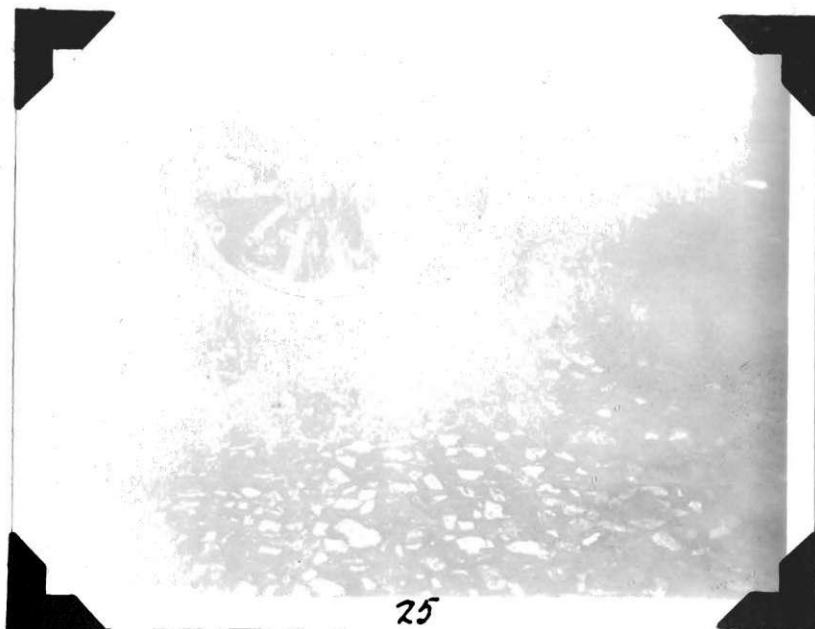
DURING THE EARLIER STAGES OF LIFE OF THIS SURFACE UNDER TRAFFIC, IT PASSES THROUGH TWO STAGES OF WEAR. THE FIRST IS THE WEARING OFF OF THE MORTAR ON THE SURFACE AND EXPOSING THE SURFACE ROCK. THE SECOND IS THE BRINGING INTO EXISTENCE OR THE EXPOSING TO TRAFFIC OF A SURFACE THAT IS COMPOSED PRINCIPALLY OF EXPOSED SURFACES OF A HARD, DURABLE STONE SURROUNDED AND HELD IN PLACE BY COMPARATIVELY THIN MORTAR JOINTS. IN THE FIRST STAGE OF WEAR IT IS SOMETIMES POSSIBLE TO DISTINGUISH THE "BOARD MARKS" IN THE MORTAR SURFACE. A CLOSE STUDY OF THESE HOWEVER SHOWS THAT IT IS MORE A SLIGHT DIFFERENCE IN THE TEXTURE OF THE MORTAR AT THESE PLACES RATHER THAN ANY A DIFFERENCE IN THE RATE OF WEAR OF THIS SURFACE. THE TEXTURE OF THE MORTAR UNDER THE BOARDS IS SLIGHTLY FINER OR NOT SO

SANDED IN APPEARANCE AS THAT WHERE THE SPACES BETWEEN THE BOARDS WERE. EXAMINATION WITH A HIGH POWER MAGNIFYING GLASS SHOWS A SLIGHT DIFFERENCE IN THE TEXTURE, THAT WHERE THE WATER WORKED OUT BEING SLIGHTLY MORE SANDY DUE TO THE EFFECT OF THE WATER FORCING ITS WAY OUT THROUGH THIS NARROW STRIP AND THUE PREVENTING THIS MORTAR FROM BEING AS THOROUGHLY COMPACTED AS THAT UNDER THE STRIPS. THIS DIFFERENCE IS ONLY RIGHT ON THE SURFACE AND DOES NOT EXTEND TO AN APPRECIABLE DEPTH AND THEREFORE DOES NOT HARM BUT SIMPLY GIVES THE PAVEMENT A MARKED APPEARANCE DURING THE EARLY STAGE OF ITS WEAR. EVEN IF THESE MARKINGS WERE DUE TO UNEVEN WEAR THEY WOULD NOT HAVE A VERY DETRIMENTAL EFFECT ON THE PAVEMENT AS PUT DOWN BY THE VIBROLITHIC COMPANY IN THE SECTION OF THE COUNTRY AS THE STRIPS RUN IN THE DIRECTION OF THE LINE OF TRAVEL WHILE IN THE OTHER SECTIONS THE STRIPS RUN ACROSS THE VIBRATING PLATFORMS. THEN AS TIME GOES ON THE MORTAR WEARS OFF AND THE SURFACE ROCK BEGINS TO SHOW AND AS THIS WEARS A LITTLE DEEPER MORE ROCK IS EXPOSED AND EACH INDIVIDUAL ROCK HAS A LARGER AREA ESPOSED TO WITHSTAND TRAFFIC. EXAMINATION OF SUCH A SURFACE SHOWS A VERY HIGH PERCENTAGE OF THE SURFACE TO BE COMPOSED OF THE SURFACING ROCK, WHICH IS OFTEN TIMES A LIMESTONE OR TRAP ROCK OR OTHER HARD ROCK, AND THE MORTAR JOINTS SMALL SO THAT THE LARGER PERCENTAGE OF THE AREA IS THE ROCK ITSELF. THIS IS SHOWN FAIRLY WELL IN THE FOLLOWING PICTURE WHICH WERE TAKEN IN THE RAIN AND THEREFORE DO NOT BRING OUT THE DETAILS AS WELL AS MIGHT BE DESIRED BUT STILL WILL ILLUSTRATE THE POINT.



24

PICTURE NO. 24. THE BOARD MARKS ARE FAINTLY VISIBLE IN THE IMMEDIATE FOREGROUND OF THIS PICTURE. THIS PICTURE WAS TAKEN IN THE RAIN AS THESE MARKINGS ARE SO FAINT THAT THEY DID NOT SHOW UP WHEN THE SURFACE WAS DRY.



25

PICTURE NO. 25. HERE MAY BE SEEN THE ROCK PATTERN EXPOSED TO TRAFFIC ON A HEAVILY TRAVELED STREET IN ATLANTA AFTER ABOUT EIGHT YEARS SERVICE. THIS WAS ALSO TAKEN IN THE RAIN WHICH OBSCURES SOME OF THE DETAIL BUT STILL SHOWS A HIGH PERCENTAGE OF EXPOSED ROCK.



PICTURE No. 26. ANOTHER VIEW OF THE SURFACING ROCK ON NORTH AVENUE THE PAVEMENT BEING WET FROM RAIN FAILED TO SHOW IN COMPLETE DETAIL THE SURFACING ROCK AS NUMBERS OF THE PIECES WERE DARK IN COLOR AND BLENDED IN WITH THE WET MORTAR SO AS TO BE ALMOST INVISIBLE IN THE PICTURE.

FROM THE TESTS WHICH WERE GIVEN IN THIS DISCUSSION AND NUMEROUS OTHERS RUN OVER A PERIOD OF YEARS AS WELL AS CORES DRILLED FROM ALMOST EVERY CONCRETE PAVEMENT IN THE CITY AND COUNTY, THE RESULTS OF THIS STUDY MIGHT BE SUMMED UP AS FOLLOWS:

FIRST. FOR A GIVEN CEMENT CONTENT, SLABS CONSTRUCTED BY THE VIBROLITHIC METHOD SHOW GREATER STRENGTH THAN THOSE OF NORMAL OR PLAIN CONCRETE, WHEN TESTED BY THE TRANSVERSE BENDING TEST.

SECOND. THE VIBROLITHIC CONCRETE SLABS ARE MORE UNIFORM IN STRENGTH THAN THOSE OF PLAIN CONCRETE.

THIRD. THE VIBROLITHIC CONCRETE SHOWS A CONTINUED INCREASE IN STRENGTH AS THE SAMPLES ARE OLDER, INDICATING THAT VIBRATION DOES NOT PRODUCE A HIGH EARLY STRENGTH ALONE AND THEN DROP BACK UNTIL THE PLAIN CONCRETE CATCHES UP WITH IT BUT THIS HIGHER STRENGTH WAS FOUND ON SAMPLES EIGHT AND NINE YEARS OLD THAT WERE TESTED.

F FOURTH. ABSORPTION TESTS SHOW ONLY A VERY SLIGHT DIFFERENCE IN THE ABSORPTION PROPERTIES OF THE TWO TYPES OF CONCRETE SO THAT THIS TEST DOES NOT SEEM TO INDICATE ANY SUPERIORITY OF ONE TYPE OVER THE OTHER.

FIFTH. COMPRESSION TESTS MADE ON CORES DRILLED FROM THE STREETS ACTUALLY UNDER SERVICE, SHOWED A HIGHER STRENGTH FOR THE VIBROLITHIC CONCRETE AS WELL AS THE TRANSVERSE BENDING TESTS MADE ON BOTH SLABS AND BEAMS.

FROM TESTS MADE BY THE BUREAU OF PUBLIC ROADS IT WAS FOUND THAT IF A 1-2-3 $\frac{1}{2}$ MIX WERE USED, THE 9" DEPTH OF VIBROLITHIC WOULD BE THE EQUAL IN STRENGTH TO PLAIN CONCRETE OF THE SAME MIX AND 9.6 INCHES THICK. DESIGNING FOR THE SAME WHEEL LOAD AND USING A 1-2-4 MIX, A DEPTH OF 9.7 INCHES OF VIBROLITHIC WOULD BE EQUAL TO 10.3 INCHES OF PLAIN CONCRETE. THIS NECESSARILY MAKES AN APPRECIABLE SAVING OF MATERIALS SO THAT ANY INCREASE IN THE COST OF FINISHING BY THE VIBROLITHIC METHOD WOULD BE OFFSET BY A LESSER COST OF MATERIALS.

IN CONCLUSION THE RESULTS OF THIS STUDY MIGHT BE SUMMED UP AS FOLLOWS:

THE VIBROLITHIC CONCRETE IS FOUND TO BE A MORE UNIFORM PRODUCT.

THE VIBROLITHIC CONCRETE SHOWS A GREATER STRENGTH FOR A GIVEN CEMENT CONTENT.

VIBROLITHIC CONCRETE WHEN TESTED AS A BEAM OR SLAB, SHOWED ONLY SMALL VARIATION WITH THE TENSION IN EITHER THE TOP OR BOTTOM.

PLAIN CONCRETE SHOWED A MARKED DECREASE IN STRENGTH WHEN TESTED IN THIS MANNER AND THE TENSION WAS IN THE BOTTOM.